

CLAIMS

What is claimed is:

1 1. An alignment system for aligning an end of an optical fiber with an input of an
2 optical waveguide of an optical device, the system comprising:
3 a lens that receives light from an output of the optical waveguide, and focuses
4 the received light into a light beam, the optical waveguide corresponding to an optical
5 path extending from the input of the optical waveguide, through the optical device to
6 the output of the optical waveguide;
7 a single optical sensor, the optical sensor receiving the focused light beam, the
8 optical sensor converting the light beam focused thereon by the lens into
9 corresponding electrical signals; and
10 processing logic, the processing logic receiving the electrical signals and
11 processing the electric signals to determine whether or not said end of the optical fiber
12 is aligned with the input of the optical waveguide.

1 2. The alignment system of claim 1, wherein if the processing logic determines
2 that said end of the optical fiber is not aligned with the input of the optical waveguide,
3 the processing logic generates a feedback signal that is sent to a motion control
4 system that controls the spatial positioning of the end of the optical fiber, and wherein
5 when the feedback signal is received by the motion control system, the motion control
6 system adjusts a spatial positioning of the end of the optical fiber in accordance with
7 the received feedback signal.

1 3. The alignment system of claim 1, wherein after the motion control system
2 adjusts the spatial positioning of the optical fiber in accordance with the received
3 feedback signal, light received by the lens from the output of the optical fiber is again
4 converted into a beam of light by the lens and focused onto the optical sensor, and
5 wherein the optical sensor generates electrical signals that the processing logic
6 analyzes to determine whether the end of the optical fiber is aligned with the input of
7 the optical fiber, and wherein if the processing logic determines that the end of the
8 optical fiber is not aligned with the input of the optical waveguide, the processing
9 logic generates a feedback signal that is sent to a motion control system that controls
10 the motion of the of the end of the optical fiber, and wherein when the feedback signal

11 is received by the motion control system, the motion control system again adjusts the
12 spatial positioning of the end of the optical fiber

1 4. The alignment system of claim 3, wherein the processing logic will continue
2 to generate and send feedback signals to the motion control system to cause the spatial
3 positioning of the end of the optical fiber to be adjusted until the processing logic
4 determines that the end of the optical fiber is aligned with the input of the optical
5 waveguide.

1 5. The alignment system of claim 1, wherein the single optical sensor is a single
2 photodiode, and wherein the lens focuses the light received thereby from the output of
3 the optical waveguide onto the photodiode and the photodiode converts the light
4 focused thereon into said corresponding electrical signals that are processed by the
5 processing logic to determine whether or not the end of the optical fiber is aligned
6 with the input of the optical waveguide, the photodiode being capable of seeing
7 outputs of multiple optical waveguides.

1 6. The alignment system of claim 5, wherein the processing logic determines
2 whether or not the end of the optical fiber is aligned with the input of the optical
3 waveguide by performing an alignment algorithm, and wherein the alignment
4 algorithm receives the electrical signals generated by the single photodiode after the
5 electrical signals generated by the photodiode have been processed by an electrical
6 processing circuit of the processing logic, and wherein the alignment algorithm
7 analyzes the processed electrical signals and determines whether or not the end of the
8 optical fiber is aligned with the input of the optical waveguide, wherein if the
9 alignment algorithm determines that the end of the optical fiber is not aligned with the
10 input of the optical waveguide, the processing logic performing the alignment
11 algorithm generates and sends a feedback signal to the motion control system that
12 cause the motion control system to adjust the spatial positioning of the end of the
13 optical fiber.

1 7. The alignment system of claim 6, wherein, in order to determine whether the
2 end of the optical fiber is aligned with the input of the optical waveguide, the motion
3 control system causes the end of the optical fiber to be scanned across one or more
4 layers of the optical device in accordance with the feedback signals received by the
5 motion control system until the processing logic determines that a layer in which the
6 optical waveguide exists has been found, and wherein after the processing logic
7 determines that the layer in which the optical waveguide exists has been found, the
8 processing logic generates and sends feedback signals to the motion control system to
9 cause the motion control system to scan the end of the optical fiber along the layer in
10 which the optical waveguide exists until the processing logic determines the location
11 of the input of the optical waveguide within the layer in which the optical waveguide
12 has been determined to exist.

1 8. The alignment system of claim 7, wherein, in addition to the electrical
2 processing circuit, the processing logic comprises:
3 an analog-to-digital converter (ADC) that converts the output of the electrical
4 processing circuit into a digital signal; and
5 a computer in communication with the ADC, the computer receiving the
6 digital signal from the ADC, the computer performing the alignment algorithm, the
7 alignment algorithm processing the digital signals received from the ADC to
8 determine whether or not the spatial positioning of the end of the optical fiber is
9 aligned with the input of the optical waveguide.

1 9. The alignment system of claim 8, wherein the processing logic further
2 comprises:
3 a differential operational amplifier, the differential operational amplifier
4 receiving two signals from the electrical processing circuit and obtaining a difference
5 signal that corresponds to the difference between the two signals, the differential
6 operational amplifier outputting the difference signal to the ADC.

1 10. The alignment system of claim 8, wherein the processing logic further
2 comprises:

3 a memory element in communication with the computer, the memory element
4 storing electrical signatures that correspond to layers of the optical device, and
5 wherein the alignment algorithm compares stored signatures with the digital signals
6 received from the ADC to determine when the layer in which the optical waveguide
7 exists has been found so that the computer can send a feedback signal to the motion
8 control system to cause the motion control system to stop scanning the end of the
9 optical fiber across the layers of the optical device and to maintain the optical fiber at
10 its current position.

1 11. The alignment system of claim 8, wherein the ADC is installed in the
2 computer.

1 12. The alignment system of claim 8, wherein the ADC is located between
2 electrical processing circuit and the computer.

1 13. The alignment system of claim 8, wherein the ADC is comprised by the
2 electrical processing circuit.

1 14. The alignment system of claim 8, wherein the electrical processing circuit
2 comprises amplification circuitry and filtering circuitry, the amplification circuitry
3 amplifying the electrical signals received from the single photodiode, the filtering
4 circuitry filtering noise out of the amplified electrical signals, the filtering circuit
5 outputting the amplified and filtered electrical signals to the ADC, the ADC
6 converting the amplified and filtered signals into digital signals that are input to the
7 computer.

1 15. The alignment system of claim 8, wherein the alignment algorithm being
2 performed by the computer produces information relating to magnitudes of the
3 electrical signals output from the single photodiode as a function of the layers of the
4 optical device while the end of the optical fiber is being scanned across the layers by
5 the motion control system, and wherein the alignment algorithm determines which
6 electrical signals output from the photodiode have the greatest magnitudes and, of the
7 electrical signals having the greatest magnitude, which of the electrical signals is most
8 likely to correspond to the layer in which the optical waveguide exists, wherein once
9 the alignment algorithm determines which of the electrical signals is most likely to
10 correspond to the layer in which optical waveguide exists, the alignment algorithm
11 sends feedback signals to the motion control system to cause the motion control
12 system to keep the position of the end of the optical fiber within the layer determined
13 to be the layer in which the optical waveguide exists.

1 16. The alignment system of claim 15, wherein as the motion control system
2 keeps the position of the end of the optical fiber within the layer determined to be the
3 layer in which the optical fiber exists, the alignment algorithm generates feedback
4 signals that cause the motion control system to move the end of the optical fiber over
5 the layer determined to be the layer in which the optical fiber exists, wherein while
6 the motion control system causes the end of the optical fiber to be scanned over the
7 layer, the computer produces information relating to magnitudes of the electrical
8 signals output from the single photodiode as a function of positions of the end of the
9 optical fiber within the layer of the optical device in which the optical waveguide has
10 been determined to exist, wherein the alignment algorithm determines which
11 electrical signals output from the single diode correspond to the electrical signals of
12 having greater magnitudes and, of the electrical signals that have the greatest
13 magnitudes, the alignment algorithm differentiates between the electrical signals that
14 have great magnitudes caused by noise and the electrical signal having the greatest
15 magnitude that does not correspond to noise, and wherein the alignment algorithm
16 determines that the electrical signal having the greatest magnitude that does not
17 correspond to noise is the input of the optical waveguide and that the end of the
18 optical fiber is aligned with the input of the optical waveguide device.

1 17. A method for aligning an end of an optical fiber with an input of an optical
2 waveguide of an optical device, the method comprising the steps of:
3 receiving light from an output of the optical waveguide with a lens that
4 focuses the received light into a light beam, the optical waveguide corresponding to
5 an optical path extending from the input of the optical waveguide, through the optical
6 device to the output of the optical waveguide;
7 focusing the light beam onto a single optical sensor;
8 converting, via the optical sensor, the light beam into corresponding electrical
9 signals; and
10 processing the electrical signals produced by the optical sensor with
11 processing logic to determine whether or not the end of the optical fiber is aligned
12 with the input of the optical waveguide.

1 18. The method of claim 17, wherein if, during the processing step, a
2 determination is made that the end of the optical fiber is not aligned with the input of
3 the optical waveguide, the method further comprises the steps of:
4 generating a feedback signal;
5 sending the feedback signal to a motion control system that controls the
6 motion and positioning of the of the end of the optical fiber; and
7 adjusting a spatial positioning of the end of the optical fiber in accordance
8 with the feedback signal received by the motion control system.

1 19. The method of claim 18, wherein the focusing, converting, processing,
2 generating, sending and adjusting steps are performed until a determination is made
3 that the end of the optical fiber is aligned with the input of the optical waveguide.

1 20. The method of claim 17, wherein the single optical sensor is a single
2 photodiode.

1 21. The method of claim 19, wherein, in order to determine whether the end of the
2 optical fiber is aligned with the input of the optical waveguide, the motion control
3 system causes the end of the optical fiber to be scanned across one or more layers of
4 the optical device in accordance with the feedback signals received by the motion
5 control system until the processing logic determines that a layer in which the optical
6 waveguide exists has been found.

1 22. The method of claim 21, wherein if, during the processing step, the processing
2 logic determines that the layer in which the optical waveguide exists has been found,
3 the steps of generating and sending feedback signals and the step of adjusting the
4 spatial positioning of the end of the optical fiber are performed with respect to the
5 layer in which the optical waveguide has been determined to exist such that the
6 motion control system causes the end of the optical fiber to be scanned along the layer
7 in which the optical waveguide has been determined to exist until a determination is
8 made that the location of the input of the optical waveguide within the layer in which
9 the optical waveguide exists has been found.

1 23. An alignment computer program for aligning an end of an optical fiber with an
2 input of an optical waveguide of an optical device, the program being embodied on a
3 computer readable medium, the program comprising:
4 an alignment routine for processing electrical signals produced by a single
5 optical sensor that have been converted into digital signals by an analog-to-digital
6 converter to determine whether or not the end of the optical fiber is aligned with the
7 input of the optical waveguide.

1 24. The program of claim 23, wherein the alignment routine comprises:
2 a first code segment for analyzing the digital signals corresponding to
3 electrical signals output from a single optical sensor when light from an output of the
4 optical waveguide is focused by a lens onto the single optical sensor, the first code
5 segment analyzing the digital signals to determine whether the end of the optical fiber
6 is aligned with the input of the optical waveguide;
7 a second code segment for generating feedback signals in accordance with the
8 determination made by the first code segment; and
9 a third code segment for casing the feedback signals to be sent to a motion
10 control system that controls the motion and positioning of the of the end of the optical
11 fiber.

1 25. The program of claim 24, wherein the routine is performed repeatedly, if
2 necessary, until the first code segment determines that the end of the optical fiber is
3 aligned with the input of the optical waveguide.